ANNUAL REPORT

OF THE

DIRECTOR, UNITED STATES COAST AND GEODETIC SURVEY

FOR THE

FISCAL YEAR ENDED JUNE 30, 1945

U. S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY
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National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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March 22, 2005

INTRODUCTION

Although an annual report is intended to be a picture of progress, in the case of extensive continuous operations, such as those of the Coast and Geodetic Survey, it is possible to present only a part of the picture in the report for any single year. And it becomes desirable, from time to time, to restate in general terms, the program of activities originally planned for the Bureau, how that program has been expanded with our growing commerce and industry, and what has been accomplished towards its fulfillment in order to fashion a background for that portion of the progress picture represented by the work of the current fiscal year. The present report provides such a background.

A-4091-10(31)+

The year just closed, like the three previous ones, has seen our major activities directed toward a furthering of the war effort. In almost every branch of our work there has been a concentration on meeting the needs of the Armed Forces and other war agencies. This war more than any other has demonstrated the close relationship that exists between the Bureau's work and the successful operations of our land, sea, and air forces. No naval task force would venture forth unless equipped with charts of the combat area, and no bombing squadron could successfully complete its mission without charts showing the military and industrial objectives sought. When our naval and military forces reentered Philippine waters they had available excellent charts which were the results of surveys made by the Coast and Geodetic Survey over a period of forty years. These surveys made possible the preparation of the special types of landing charts and related information needed in the amphibious operations.

With the end of the war, our immediate task ahead will be channelling back our activities to a peacetime orientation. With full knowledge of the importance of basic mapping programs in the commercial and industrial life of our Nation, we shall continue to serve these interests as we have served our military interests during the war years, and provide the fundamental data necessary to execute such programs commensurate with an expanding and developing America.

AN ACT TO PROVIDE FOR SURVEYS OF THE COASTS

The necessity for maps and charts of the coast and harbors of the country for the benefit of commerce and navigation was early appreciated by Congress which on February 10, 1807 approved the organic act establishing this Bureau, reading as follows:

Sec. 1. That the President of the United States shall be, and he is hereby, authorized and requested to cause a survey to be taken of the coasts of the United States, in which shall be designated the islands and shoals, with the roads or places of anchorage, within twenty leagues of any part of the shores of the United States; and also the respective courses and distances between the principal capes, or headlands, together with such other matters as he may deem proper for completing an accurate chart of every part of the coasts within the extent aforesaid.

Sec. 2. That it shall be lawful for the President of the United States to cause such examinations and observations to be made with respect to St. George's Bank, and any other bank or shoal and the soundings and currents beyond the distance aforesaid to the Gulf Stream, as in his opinion may be especially subservient to the commercial interests of the United States.

Sec. 3. That the President of the United States shall be, and he is hereby, authorized and requested, for any of the purposes aforesaid, to cause proper and intelligent persons to be employed, and also such of the public vessels in actual service, as he may judge expedient, and to give such instructions for regulating their conduct as to him may appear proper, according to the tenor of this act.

Sec. 4. That for carrying this act into effect there shall be, and hereby is, appropriated a sum not exceeding

fifty thousand dollars, to be paid out of any monies in the treasury, not otherwise appropriated.

The work of carrying out the provisions of this act was entrusted by the President to the Treasury Department. With the creation of the Department of Commerce and Labor in 1903, the Survey was transferred to that Department, and in 1913 when the Department of Labor was created, the Coast and Geodetic Survey remained in what was thenceforth designated as the Department of Commerce.

The provisions of the organic act have been modified and added to from time to time by subsequent legislation and the work of the Bureau, as is implied by its present name (United States Coast and Geodetic Survey - adopted in 1878), has been enlarged into what is broadly spoken of as two distinct fields of activity. These are surveying the coasts of the United States, Alaska, and our island possessions, generally spoken of as hydrographic surveys, and surveying in the interior, called geodetic surveys, which consists of the establishment of the control or framework on which all land surveys, federal, state, municipal, and industrial are or should be based.

Two important activities, not contemplated in the original act, have been added to the functions of the Bureau in recent years. One is earthquake investigation known as seismology - transferred by the Congress in 1925 from the Weather Bureau, and the other is the preparation of aeronautical charts, delegated to the Secretary of Commerce under the Air Commerce Act of 1926.

The Coast and Geodetic Survey can be likened to a comprehensive manufacturing establishment. Our surveying parties go into the field and gather the raw materials. Those raw materials are shipped to Washington where the central plant is located. In this plant the materials are worked over and from them are derived certain final products in forms suitable for public use. These products invariably take the form of publications, and the final and culminating step in the process is the quantity production of these publications. Charts and maps are produced in our own printing plant. Other publications are printed at the Government Printing Office.

The products furnished the public for its use consist of:

The nautical chart
Related nautical publications
Control surveys in the interior
Tide and current tables
Geomagnetic surveys
Seismological investigations
Aeronautical charts

CHARTING OUR COASTAL WATERS

One of the principal products of the Bureau's activities is the nautical chart. Its importance to our commercial and industrial development was recognized at an early period in the history of our country. The duty of surveying and charting the approaches to the shores of a nation stands high on the list of international obligations for the promotion of the interests of one of the greatest civilizing

agencies - international water-borne commerce. Without adequate charts, free and unrestricted intercourse by water would be impossible, the defense of the shores of any nation would be feeble, and its harbors as effectively closed to the commerce of the world as though blockaded by an enemy fleet. Charts are essential not only for our own Navy and Merchant Marine, but it is just as important that they be available to foreign vessels plying our waters, if they are to engage in commerce with us.

The function of the nautical chart is to safeguard our seaways. It keeps commerce informed as to hydrographic conditions. It guides the mariner over what has often been called the "trackless sea." It directs him to the lanes of travel that are safe, and warns him of the rocks and the shoals that may bring him to grief. The chart is a basic implement of water-borne commerce, as essential to the ship as the compass, radio, or the rudder. As our ports and harbors grow, the charts must grow with them. The millions spent annually on harbor improvements, port facilities, lighthouses, and buoys, as well as the elaborate hydrographic and topographic surveys made by this Bureau, would fail of their full purpose if these changes and improvements were not shown on the charts.

To cover our extensive coastline, some 870 different charts are published at the present time. Charts are designed on several scales to meet the different needs of navigation. The scale of a chart generally determines the amount of detail that it is possible to include, and this in turn determines the use to which the chart can be put. At one end there is the chart designed for offshore navigation between distant ports. These must embrace large areas, hence the scale must be made small. Details on such charts are of secondary importance. At the other end are the charts designed for navigation in harbors, which require a maximum of detail consistent with clarity and legibility. Such charts being of limited extent can be constructed on much larger scales, thus permitting fullness of detail in topographic and hydrographic features including the channels to be followed, the position of lights, beacons, buoys, and prominent landmarks from which the mariner can identify his position as he comes to a safe anchorage. Between these two extremes there are other series of charts that are required to safeguard navigation. For example, in the vicinity of New York there are five different chart series on scales ranging from 1:10,000 to 1:1,200,000.

THE NAUTICAL CHART IS A PERISHABLE PRODUCT

There is one characteristic of nautical charts that perhaps does not have an exact counterpart in any other branch of mapping, and that is its perishable nature. The nautical chart is one type of map that cannot be shelved or forgotten about once it is printed. A chart that contains faulty information can frequently turn out to be worse than no chart at all, because of the false confidence it creates.

The publication of a chart, therefore, by no means completes the work of the Bureau in that locality. Charts must be kept alive if they are to serve their purpose properly. They must be revised frequently to give an accurate

and up-to-date picture of existing conditions. The coastal region, which it portrays, is the zone where two great physical provinces meet - the land and the sea - and where constant changes are in progress, due alike to natural forces and to the works of man. Ocean waves and currents are constantly taking material from one place and depositing it in another, as is evidenced by the westward growth of Rockaway Point, Long Island-- a growth of over 4 miles in 100 years. Rivers empty vast quantities of sediment near their mouths to build out the coastline, a striking example of this being the Mississippi. In times of heavy storm, barrier beaches are often broken through to form inlets of a temporary or permanent nature. Bars and channels are constantly shifting. Men are dredging channels, filling up tide flats and building their manufacturing plants or terminal facilities upon them, and establishing or shifting lighthouses, beacons, and buoys to conform to the changing demands of commerce.

The charts must be kept corrected to show all these changes. This means that each edition of the chart of any of our important seaports soon becomes obsolete and must be superseded by a new edition showing the changes that have occurred since the preceding one was printed. In the case of the New York Harbor Chart, it has been found necessary to print it about four times a year. Between printings, important corrections, such as changes in lights, buoys, beacons, recently reported dangers, and other critical information are applied by hand before the chart is issued to the public. Once issued, changes in the chart are published in the weekly Notices to Mariners, which the navigator uses to apply to his chart until a new edition is issued which cancels all existing editions. The locations of outstanding dangers, newly discovered, are furnished him by radio. Every effort is thus being made to keep the navigator fully informed of vital changes in the chart.

CHARTING OUR AIRWAYS

Because of the basic similarity between nautical and aeronautical charts, the Bureau was instructed under the Air Commerce Act of 1926, "to provide as adequate charts for air navigation as it now provides for ocean navigation." In fulfillment of this directive, the Bureau has compiled and printed approximately 500 aeronautical charts of the United States and its possessions. These range from large-scale charts for piloting and contact flying to small-scale charts for use in the navigation of high-speed transports, special charts for radio navigation, and charts for instrument approach and landing procedures. Some fifty miscellaneous sources are used in compiling these charts. Upon the basic chart, airports, beacon lights, radio range stations and other aeronautical data are over-printed, usually in red. These charts must be kept current, particularly for the aeronautical data, in order to provide the aviator with knowledge of existing conditions.

An important phase in the preparation of an aeronautical chart is the flight check. To insure accuracy of the detail shown, the charted area is flown over, before final publication, by an experienced observer and details on the chart are compared with the ground below. Necessary correc-

tions are indicated, and any prominent landmarks are noted for addition to the charts. Some of the most important information of ground conditions is obtained for the aviator from the flight check.

A text on air navigation, prepared by one of the Survey's cartographic engineers, has been adopted as a standard text by the Civil Aeronautics Administration, and is now published as Civil Aeronautics Bulletin No. 24 ("Practical Air Navigation").

CHART PRODUCTION

During the past year there has been a marked increase in the demand for charts for use in the Pacific. A total of 21,230,000 copies of charts was issued during the year, a slightly greater number than was issued during the previous year. The slight decrease in aeronautical charts was more than offset by the increase in nautical charts. The relative annual output of navigational charts and related publications for the past four years is given in the following table:

Charts and publications issued

Type of chart or publication	1942	1943	1944	1945
Nautical charts	1,081,072	1,916,599	2,913,666	4,330,547
Aeronautical charts	3,145,516	11,773,464	17,645,892	16,899,049
Coast Pilots	19,094	35,661	16,086	13,884
Tide Tables	35,496	56,109	81,449	98,016
Current Tables	21,825	36,698	86,038	40,933

The number of individual nautical charts published at the end of the year was 873. To produce the 4,300,000 copies, 1321 printings were made, as follows: 10 new charts, 79 new editions, 716 new prints, and 516 reprints. Due to rapid changes in navigational data, it was necessary to apply 7,078,640 hand corrections to correct the charts to date of issue. Dangers requiring hand corrections and other navigational information were reported to the Coast Guard and Hydrographic Office for publication in the weekly Notice to Mariners. Of the 10 new standard charts published, 4 were constructed for the Navy and 2 for the Coast Guard.

The standard aeronautical charts of the United States and possessions, 134 in number, were maintained as to aeronautical data. While a few major revisions of base information were made, only minor revisions and spot corrections were possible for the most part, leaving a considerable reservoir of unapplied source material.

In addition to these standard charts, the production of 447 instrument approach and landing charts was in process by the end of the year. This series of charts, of which 371 have been printed, is increasing in importance.

During the year there were 1507 printings of aeronautical charts, as follows: 476 new charts, 260 new editions, 524 revisions, and 247 reprints. The printings included 9,484,000 United States charts, while 7,415,000 were of foreign areas. Approximately 16,000,000 aeronautical charts were issued to the Armed Forces.

Nine flight check parties were in the field during the year. About 80 percent of the United States has now been flight checked. When the entire country is completed, constant flight check inspection will be maintained so that each chart will be inspected about once every three years.

A field station was established in Kansas City, Missouri, on 29 January 1945. The purpose was to direct the operation of field parties engaged in the flight checking of aeronautical charts; to distribute aeronautical charts to 82 authorized chart agencies within the Mississippi River basin; to establish working contacts with federal, state, and public organizations interested in mapping and charting with a view toward maximum mutual utilization of available information; and insofar as possible with funds available, to maintain, or replace where lost, the triangulation, leveling, and magnetic stations within this region. The establishment of this regional distribution facility has greatly relieved the cramped and overburdened facilities of the Washington Office.

Because of the difficulty of obtaining draftsmen for hand-correcting charts, a unit was set up in the Baltimore field office. Trips were made three times a week by truck to and from Baltimore in order that corrected copies could be issued in response to requests. An average of 200,000 corrections per month have been made by that office through the year.

In addition to the production of the standard nautical and aeronautical charts, the following special war work has been performed: Production of tide and light diagrams for amphibious operations; bombardment charts of the Philippines for use of surface vessels in softening objectives prior to invasion; target charts for industrial and tactical bombardment, including special devices; special air navigation charts, weather charts, planning charts, and direction finding charts, for military use; magnetic studies and analyses for isogonic lines and development of specifications for fluorescent chart paper for military use; preparation of damage plans and fire susceptibility plans; special plotting and navigation tables and devices; special projection computations and construction; relief models for military needs; photo indexing of military photography; research and evaluation of mapping material; maps and route manuals and handbooks; and operational airfield index charts for allied military use.

Special war work was performed for the Maritime Commission, Weather Bureau, Coast Guard, Civil Aeronautics Administration, Petroleum Administration for War, N.D.R.C., Department of State, Government Printing Office, Tennessee Valley Authority, Bureau of Foreign and Domestic Commerce, Census Bureau, War Manpower Commission, and Federal Communications Commission.

Reproduction for the Civil Aeronautics Administration of the bi-monthly publication, Radio Aids to Navigation, was continued throughout the year.

The large amount of printing required during the year has again exceeded the capacity of the plant, and it has been necessary to send a considerable quantity of printing to the four commercial firms with whom contracts were negotiated last year. In general it has been found far more satisfactory to process material directly to the contractor's

printing plates than to send drawings, negatives, or plates to the contractor.

COASTAL SURVEYS

Coastal surveys, which include hydrography, topography, and coastal triangulation, provide the fundamental data for the production of nautical and aeronautical charts. These surveys are carried on by ships and shore-based units to obtain information concerning obstructions to navigation, locations of channels, characteristics of the sea bottom, shorelines and other topographic features along the coasts, and much other data required for the production of marine charts and coast pilots.

When the Coast Survey was first organized, its work included only the coastal strip along the Atlantic Coast comprising about 15,000 statute miles. With the Nation's territorial expansion the activities of the Bureau have grown until today its jurisdiction extends to all the waters of continental United States, Alaska, the Philippines, Guam, the Hawaiian Islands, Puerto Rico, the Canal Zone, and the Virgin Islands -- comprising a total shoreline of over 100,000 statute miles. The vast coastal waters fringing this shoreline cover a total area of well over a million square miles. Many sections of our coastline are changing constantly, in varying degrees, due to natural causes and the works of man. Changes are likewise taking place in the ocean bottom. Shifting of channels and other features, and waterfront developments and harbor improvements, require continual and extensive changes in the systems of aids to navigation.

Before the war, water areas averaging about 40,000 square miles were surveyed annually in order to obtain information concerning these changes and to provide additional charts required on account of commercial developments. This was sufficient to maintain reasonably accurate charts of commercially important areas; that is, important ports, the approaches thereto, and the water lanes between them. Regions of lesser commercial importance have been neglected for many years, present charts in many cases being based upon surveys from 40 to 50 years old. There has been neglect of numerous coastal areas used for recreation and by small local industries. Annual surveys of 40,000 square miles of water area may, therefore, be considered the minimum workload for hydrographic surveys under present conditions, but this minimum should not be considered a yardstick for the charting needs of the people of this nation in these modern times. New navigational devices, such as the echo-sounding machine, have made many of our early surveys in deep water inadequate because they lack the detail which the modern navigator requires for use with his improved instruments. Such areas must be re-surveyed in order that the charts may be modernized.

During the year 12 survey ships and several shore-based units were engaged on coastal surveys. Five ships which were transferred to the Navy at the beginning of the war are still assigned to the Navy. Practically all field operations were directed to complying with requests from the Army and Navy for surveys and investigations in strategic

areas. A summary of the results accomplished is given in the following table:

Statistical summary of coastal surveys

Locality	Hydrography				Topography		Coastal triangulation		
	Sounding lines	Area	Wire drag	Area	Shoreline	Area	Length of scheme	Area	Geographic positions
	Miles	*Square miles*	*Miles*	*Square miles*	*Miles*	*Square miles*	*Miles*	*Square miles*	*Number*
Coast of Maine	3,276	179	124	22	548	179	—	—	55
Atlantic coast, Mass. to Cape Charles, Va.	1,517	51	36	9	65	27	—	—	—
Chesapeake Bay	4,648	205	88	32	398	208	13	29	49
Florida	—	—	—	—	372	435	—	—	—
San Francisco Bay	—	—	—	—	131	44	—	—	—
Puget Sound	414	22	5	1	8	—	63	260	169
Alaska	12,455	2,043	42	12	217	18	464	5,755	271
Total	22,310	2,500	295	76	1,739	911	540	6,044	544

On the Atlantic coast, the LYDONIA, GILBERT, and FARIS made hydrographic surveys, and the HILGARD and WAINWRIGHT made wire-drag surveys along the coast of Maine. These surveys are a continuation of work requested by the Navy surveys are a continuation of work requested by the Navy in Casco Bay and waters in the vicinity of Portland, Maine, and cover waters patrolled by combat vessels. Hydrographic surveys were completed in Merrymeeting Bay and the Androscoggin River, Muscongus Bay, Medomak River, the St. George River, and an area at the western side of the entrance to Penobscot Bay. Wire-drag surveys were completed in New Meadows River, the Sheepscot River, and in the approaches to the Damariscotta River.

A winter project of hydrography was carried on in Chesapeake Bay by the LYDONIA and COWIE. Surveys were completed in the Choptank River and tributaries, and work was carried on in Chesapeake Bay in the approaches to the Choptank River.

The GILBERT made hydrographic surveys in the James River, Virginia, in the vicinity of Fort Eustis, and in the Chickahominy River. The survey in the vicinity of Fort Eustis was requested by the Maritime Commission as an urgent project.

The GILBERT, HILGARD, and WAINWRIGHT made hydrographic and wire-drag surveys in Narragansett Bay, Rhode Island, for the Naval Air Station at Quonset Point.

Hydrographic and wire-drag surveys of Boston Harbor were made by the GILBERT, FARIS, HILGARD, and WAINWRIGHT. These surveys were urgently needed in connection with the construction of a new chart of the Boston Harbor area.

The COWIE completed triangulation in the vicinity of Chesapeake Bay, Maryland, for the Naval Research Laboratory at Randle Cliff, and cooperated with a field unit of the Naval Mine Warfare Test Station, Solomons Island, in determining with precision the location of equipment being tested in the vicinity of Cove Point, Chesapeake Bay. A hydrographic survey of the Dahlgren area was completed to meet a request of the Navy for a large-scale chart of this area. A hydrographic survey was made of the area in the vicinity of Cape Henlopen, Delaware, because it was known

that considerable changes had occurred in the shoreline and in the water depths.

The FARIS made a hydrographic survey in the James River, in the vicinity of Newport News, Virginia, and completed an extensive system of triangulation in the Hampton Roads area for the District Office of the U. S. Army Engineers at Norfolk, Virginia. At the request of the Navy the FARIS made revision surveys of Grovesend Bay, in lower New York Harbor.

The HILGARD and WAINWRIGHT accomplished wire-drag investigations of wrecks in the entrance to Chesapeake Bay, and assisted the GILBERT in completing a hydrographic survey in the York River, Virginia, in the vicinity of the Cheatham Annex of the Yorktown Naval Mine Depot. A hydrographic survey was also made of Little Creek, Virginia. A special wire-drag survey was made in Sandy Hook Bay, in the vicinity of an Army and Navy Base. Work on these four projects was requested by the Navy.

On the Pacific coast, during the winter season and during the repair period for the ships, the EXPLORER completed a hydrographic survey and made wire-drag investigations in Neah Bay, at the request of the Navy.

The WESTDAHL completed triangulation and topography at the north end of Lake Washington, at the request of the Naval Air Station at Sand Point, and accomplished revision-triangulation work in Coos Bay, Oregon, for the District Office of the U. S. Army Engineers at Portland, Oregon.

The DERICKSON made a special hydrographic survey for the Naval Base at Smith Cove, Puget Sound, and determined a number of geographic positions for the Public Works Officer of the Navy, in the vicinity of the Navy Yard at Bremerton, Washington.

The SURVEYOR accomplished triangulation in Hood Canal, in the Puget Sound area, for determining the positions of recently established navigational aids of the Coast Guard.

In Alaska, the EXPLORER, SURVEYOR, DERICKSON, E. LESTER JONES, and PATTON made hydrographic surveys in the vicinity of Adak Islands, the Delarof Islands, Amchitka Island, Kiska Island, Shemya Island, and Attu Island for the Navy. The WESTDAHL provided transportation and assisted a geodetic-triangulation party along the Alaska Peninsula. Work was started by a shore-based unit on triangulation and hydrographic surveys in the vicinity of Point Barrow, Alaska, for the Navy.

In the Aleutian Islands coastal triangulation was extended on the North American datum of 1927, westward to Kiska Island. An attempt was made to carry this work further westward to Agattu and Shemya Islands but the connection was not completed. Triangulation was established between Attu, Agattu, and Semichi Islands.

In the Philippine Islands the Coast Survey Office at Manila was reopened by the Philippine Government by assigning a former cadet as Acting Assistant Director to perform such work as possible considering the total destruction of records, instruments, and equipment. Two small vessels were obtained by a Coast and Geodetic Survey officer in the Army in the Philippines and surveys were made in Manila Bay to determine wrecks and obtain other information.

Single-lens aerial photographs were taken of scattered areas along the Atlantic and Gulf coasts and in the south-

ern part of the country for topographic mapping or for nautical chart revision. The Gulf Intracoastal Waterway from St. Marks, Florida, to Biloxi, Mississippi, was photographed for the revision of existing planimetric maps, and thence to Houma, Louisiana, for new planimetric maps. Photographs were also taken of a number of airports near the coastline for use on airport approach charts. The United States Coast Guard cooperated with this Bureau in furnishing an airplane and crew to assist in making the aerial photographs.

Field inspection of aerial photographs and allied ground surveys were in progress along the coast of Maine, in Virginia, along the east coast of Florida, and along the south coast of the Alaska Peninsula. The photogrammetric offices at Baltimore, Maryland, and Tampa, Florida, were continued and were engaged in compiling topographic and planimetric maps based on these field surveys. Planimetric maps of the San Francisco Bay area based on previous field inspection were also compiled.

Field surveys and resurveys of airports were continued with an average of four parties in the field. Forty-eight new surveys and 222 resurveys were completed during the year. Very satisfactory progress was made in extending precise levels to the airports and in establishing permanent bench marks. During the year one airport survey party was combined with a geodetic level party which, together with other leveling parties engaged on this class of work, carried precise leveling to 372 airports.

The District Offices maintained by the Bureau at the principal ports continued to render valuable service in supplying information for the correction of charts, in disseminating nautical and engineering data in response to requests from local, public, and official sources. These offices also assist the various field parties of this Bureau in obtaining supplies, personnel, and in planning field work of the parties working in their respective districts. From local knowledge of surveys needed in the district, the District Office makes recommendations to Washington that such surveys be accomplished.

Processing Offices were continued at the two principal bases of the field parties, Norfolk, Virginia, and Seattle, Washington. The operation of these field offices expedites the transition of field surveys to the finished nautical charts and permits close cooperation between the field engineer and the office draftsman. By being relieved of a great amount of office work, the survey parties are able to engage in a year-round program of field work.

GEODETIC CONTROL SURVEYS

In surveys covering extensive areas, account must be taken of the earth's curvature in the computation of the results, otherwise serious errors will develop. Such surveys are termed geodetic surveys and represent the highest form of survey engineering. Geodetic surveys include the determination of the latitudes and longitudes (by triangulation or traverse), and elevations above sea level (by leveling) of numerous points throughout the country. They involve astronomic observations, measurement of base lines, measurement of the force and direction of gravity, and the

computation and final adjustment of all field operations required for the establishment of a consistent network of marked points and bench marks on a single basic datum of control for all surveys.

Geodetic control surveys are essential to the mapping of the country and to every engineering project requiring accurate knowledge of the horizontal and vertical relationships between points on the earth's surface.

From the very inception of the Coast Survey, control surveys have been carried on along the coasts to provide the framework for the nautical charts published by the Bureau. By the Act of 1871, the Coast Survey was recognized as the proper governmental agency to furnish the basic control for the topographic and geologic mapping of the interior of the country. This extension of geodetic surveys at first provided control points at widely spaced intervals, but with the commercial and industrial development of the country, it became necessary to break down the major arcs of triangulation into subsidiary arcs so that control points would be available for state and local surveys. For many reasons, it is in the best national interest to have all surveys - no matter how localized they may be - tied in with the national control net established by this Bureau. The extent to which this ideal is reached will depend largely upon the availability of control points to the local surveyor and engineer. It is therefore a part of the Bureau's geodetic program to establish closely spaced control points as rapidly as possible, the distribution varying in accordance with the requirements of each region. In general the distance between points should not exceed 3 or 4 miles in rich agricultural land, nor 2 or 3 miles in metropolitan and industrial regions.

Geodetic control surveys have a number of collateral uses, such as in flood prevention and conservation projects, in highway and railroad construction, in hydroelectric power development, cadastral and boundary surveys, geophysical prospecting for oil and minerals, and surveys for the development of natural resources.

During the year a number of projects have been engaged in that were of direct interest to the military organizations. A new general policy was inaugurated of determining a large number of supplemental triangulation or traverse stations at the same time the main scheme of triangulation is carried forward. These additional stations provide a closer spacing of control and of area coverage for local use, especially along the main highways where they are more readily accessible for the surveyor or engineer.

In Alaska the surveys which were initiated in 1941 at the request of the War Department have been continued in each of the following years through the use of funds advanced by the Corps of Engineers. The principal projects undertaken during the past year were the extension of the triangulation on Seward Peninsula to Nome, Cape Prince of Wales, and the Diomedes Islands in the Bering Straits, and the filling in of the gap in the triangulation between Wide and Chignik Bays on the Alaska Peninsula. Other triangulation projects in Alaska of interest to the War Department were the arcs along the Glen Highway from Anchorage, through the Matanuska Valley, to the Richardson Highway, and from Gulkana along the Tok Cutoff toward Tanacross. The latter

project was discontinued because of weather conditions before completion.

A notable achievement was the extension of the North American datum of 1927 as far west as Kiska in the Aleutian Islands group. It marks the completion of many years of observations in triangulation work which for practical reasons had to be made on different datums. All the triangulation in Alaska and the United States is now on a common datum. This is an important factor when using master stations on shore for the determination of position by electronic methods in ships at sea.

First-order leveling was extended along the Glen Highway from Anchorage to Gulkana and thence along the Tok Cutoff toward Tanacross on the Alaska Military Highway.

In the states special projects carried on for the War Department included the location of stations in the vicinity of Chicago, Ill., and in the vicinity of Belmar Beach, N. J., for the Signal Corps Laboratory at Eatontown, N. J., in connection with their experiments on the determination of distances with electronic methods.

At the request of the Ordnance Bureau, supplementary control was provided in the vicinity of the Aberdeen Proving Grounds, Md., for use in testing guns and batteries.

At the request of the Army Air Corps, additional horizontal control was provided in the vicinity of Eglin Field, Florida, for use in experiments for precision bombing.

At the request of, and in cooperation with, the Corps of Engineers, Portland District, a revision survey for triangulation in Coos Bay, Oregon, was accomplished.

Control surveys were initiated in the Columbia River Basin with funds advanced by the Corps of Engineers in connection with their plans for the development of this Basin. During the year triangulation and leveling were provided along the Snake River from Hagerman downstream toward Weiser, Idaho. These surveys will be continued in the next year in order that precise control may be made available along the Columbia River and its many tributaries.

Horizontal control was also initiated in the Missouri River Valley and first-order levels run at the request of the Missouri River division of the Corps of Engineers. These surveys are a necessary prelude to the adoption of working plans for the flood control and water power developments of the Missouri River Valley.

In Nevada, triangulation was done at the request of the U. S. Grazing Service in connection with their activities in the Meadow Wash Valley and also by the Nevada State Planning Board for the development of the resources of the state. This is one of the projects on which the party composed mostly of conscientious objectors was engaged.

Triangulation was also accomplished in Ohio, West Virginia, Mississippi, and New Mexico.

As part of a project to establish bench marks in the more important airports in the United States, levels were run to 372 airports establishing definite elevations on a common datum.

Precise astronomic observations were made in Alaska and in seven states for the control of the triangulation azimuths. Experiments were conducted with various types of astronomic instruments - the astrolabe, first-order theodolite, and Bamberg broken telescope - and with various procedures to

determine the relative accuracy, economy, and efficiency with which astronomic determinations may be made. The study is still in progress.

Precise surveys were accomplished at Carderock, Md., to provide for the extension of the David Taylor Model Basin. This basin of the U. S. Navy is used for the purpose of testing ship models and other water craft and is being extended from its present length of 1800 feet to 3300 feet in precise alignment, requiring surveys of the highest accuracy.

The astronomic observatories at Ukiah, Calif., and Gaithersburg, Md., maintained to study the variation of latitude, were continued in operation throughout the year, during which time 2900 star pairs were observed. These observatories are operating in accordance with the program, international in scope, calling for observations to be made at five widely separated observatories along the 39th parallel of latitude for use in studies to determine the variation of latitude.

The field activities during tne year are summarized in the following tables:

Triangulation

Locality	Length of scheme	Number of stations	Area
FIRST-ORDER TRIANGULATION	*Miles*		*Square miles*
Vicinity of Chicago, Ill.	40	29	400
Wide Bay to Chignik Bay, Alaska	45	27	360
Cook Inlet to Tok Junction, Alaska	185	61	2380
Redoubt Bay Base Net, Alaska	20	6	200
Vicinity of Belmar and Eatontown, N. J.	7	13	20
Lovelock Base Net, Nev.	10	7	75
Parkersburg to Charleston, W. Va. (Includes vicinity Charleston)	90	114	1260
Parkersburg, W. Va., to Logan, Ohio	45	48	585
Seward Peninsula, Alaska	130	72	2900
Moapa, Nev., to Wendover, Utah	330	167	9845
Peach Springs to Forepaugh, Ariz., and Prescott, Ariz., to Needles, Calif.	225	73	2760
Globe to Clifton, Ariz.	100	65	1810
Safford to Willcox, Ariz.	125	62	1615
Southwest Mississippi	165	150	1800
Deming to Las Cruces, New Mexico	85	43	1085
Logan to Circleville, Ohio	40	21	440
Silver City to Magdalena, New Mexico	150	54	3000
Falls City, Nebr.	15	13	180
Aberdeen Proving Grounds, Md.	10	11	80
Eglin Field, Fla.	30	9	160
Total	1847	1045	30455
SECOND-ORDER TRIANGULATION			
Snake River, Idaho and Oregon	285	209	4095
Missouri River, S. Dak.	25	32	250
Willamette River, Oregon	80	53	850
Total	390	294	5195

Base line measurement

Locality	Length of Scheme	Number of Stations
First-Order Base Lines	*Miles*	
Nakolilok, Alaska	1.7	—
Glen, Alaska	2.6	—
Arctic, Alaska	4.9	—
Ely, Nev.	8.3	—
Redoubt, Alaska	6.4	—
Lovelock, Nev.	7.7	—
Jackson, Miss.	1.9	—
Tougaloo, Miss.	2.1	—
Sunset, Ariz.	5.8	—
Parade, S. Dak.	7.2	—
Eaton, Idaho	3.2	—
Total	51.8	—
Second-Order Base Line		
Point Barrow, Alaska	2.8	—
First-Order Traverse		
Eglin Field, Fla.	4.8	7
Second-Order Traverse		
Airports, Fla.	61.4	108

Reconnaissance

Locality	Length of Scheme	Area
First-order reconnaissance	*Miles*	*Square miles*
Montello, Nevada to Twin Falls, Idaho	160	3275
Vicinity of Chicago, Illinois	40	400
Fairbanks to Circle, Alaska	75	800
Parkersburg, W. Va., to Circleville, Ohio	85	1150
Wide Bay to Chignik Bay, Alaska	45	360
Pook Inlet to Tok Junction, Alaska	185	2575
Redoubt Bay Base Net, Alaska	20	200
Vicinity of Ely, Nevada	115	2755
Vicinity of Belmar and Eatontown, N. J.	7	20
Parkersburg to Charleston, W. Va.	90	1260
Southwest Mississippi	585	7025
Benson to Tombstone, Arizona	35	460
Globe to Clifton, Arizona	100	1310
Safford to Willcox, Arizona	125	1615
Willcox to Winkelman, Arizona	180	2595
Vicinity of Deming, New Mexico	20	255
Parade Base Net, South Dakota	10	50
John Day River, Oregon	70	750
Salmon River, Idaho	65	475
Eglin Field, Florida	30	160
Williston to Minot, North Dakota	130	2600
Panhandle Area, Texas	290	3020
Total	2462	33110
Second-order reconnaissance		
Airports, Texas	145	1115
Snake River, Idaho and Oregon	315	4395
Missouri River, N. Dak., and S. Dak.	115	850
Willamette River, Oregon	80	850
Total	655	7210

Leveling

State or Region	First-order	Second-order
	Miles	*Miles*
Alabama	29	61
Alaska	322	–
Arizona	47	100
Arkansas	–	16
California	310	101
Canada	4	–
Florida	256	160
Georgia	115	60
Idaho	173	401
Iowa	5	–
Louisiana	86	7
Mississippi	60	32
Missouri	–	17
Montana	205	2
Nevada	30	38
New Mexico	25	36
Oklahoma	7	24
Oregon	21	151
South Dakota	17	76
Texas	257	281
Utah	37	21
Washington	541	87
Total	2547	1671

Astronomy

State or territory	Determinations		
	Latitude	Longitude	Azimuth
Colorado	2	2	2
Florida	–	–	8
Idado	1	1	1
Mississippi	1	1	1
Nevada	1	1	1
Ohio	2	2	–
Oregon	–	1	1
Texas	1	1	1
Alaska	7	8	8
Total	15	17	23

The office force in Washington has been engaged on the processing of the field data gathered by the triangulation and leveling parties, and on several special mathematical problems of a confidential nature in connection with the war effort. The computation and adjustment of 90 arcs and areas of triangulation were completed, resulting in the addition of 7417 geographic positions of stations expressed on the North American datum of 1927. Fourteen subordinate networks of leveling were adjusted, involving 5434 miles of line, and preliminary computations were made for 2321 miles of levels. Elevations and descriptions of 14,487 bench marks were prepared in a form for distribution. The operation of the field computing office in New York City was continued during the year and was markedly successful in relieving the processing work load in the Washington Office.

Instruction in geodetic methods of the Coast Survey was given to a number of geodesists from the Latin American countries, and to geodesists from Turkey, Poland, and China. This instruction consisted of several months of actual field experience and at least two months of experience in office methods of processing field data.

Distribution of data concerning geodetic surveys has been intensified during the past year, chiefly due to the many requests from various oil companies and geophysical prospecting companies engaged in the search for additional supplies of oil.

TIDE AND CURRENT SURVEYS

The tidal work of the Coast and Geodetic Survey had its origin in the necessity for correcting the soundings taken in hydrographic surveys for the rise and fall of the ocean tides, so that the nautical charts would show all depths reduced to a common datum. With the increased drafts of vessels it became necessary to make available to the mariner an advance knowledge of the times and heights of high and low water at the more important ports. Such information is furnished him in the form of Tide Tables which are published annually by the Bureau and issued in advance of the beginning of each year.

Besides these two principal purposes the tidal work of the Bureau has many collateral uses in the fields of practical engineering and scientific research. Among these may be mentioned its use in the determination of mean sea level at various points along the coast to serve as a basic datum for the network of leveling extended over the country; in the location and design of piers, bridges, and factories; in the determination of title to property bordering on tidewater; in the study of marine life, phenomena associated with storms and earthquakes, and in the study of the important question of coastal stability. The Coast and Geodetic Survey is the sole agency of the United States Government that is charged with this function.

Accompanying the rise and fall of the tide is a horizontal movement of the water known as the tidal current. A knowledge of the currents in a locality is a prerequisite to safe navigation. There are many cases on record where vessels have come to grief because they lacked information on currents or because they failed to take existing currents into account.

In addition to its importance in navigation, currents must be considered by the civil or military engineer, engaged in harbor improvement and marine construction, and by the sanitary engineer in dealing with the problem of sewage disposal in metropolitan districts. Information on currents is furnished to the public in the form of current tables published annually by the Bureau and in other forms.

To obtain the data for tide and current information, the Bureau operates some 80 tide stations at coastal ports, makes supplemental short-period tide observations at numerous other places, carries on combined tide and current surveys of important waterways, and analyzes data for making tide and current predictions.

During the year, the Bureau had in continuous operation 45 primary and secondary tide stations on the Atlantic and Gulf coasts, 32 stations on the Pacific coast, and under the State Department program of Cooperation with American Republics, 12 stations in Central and South America. Thirty-seven of the stations in this country were maintained on a cooperative basis with various units of the Army, Navy,

Coast Guard, and with municipal and research organizations.

A tidal bench mark recovery party accomplished good results in servicing tide stations and recovering and leveling to bench marks along the Pacific coast of the United States.

The comprehensive current survey of Puget Sound, which has progressed for short periods each winter since 1942, was completed in February 1945. Additional current data for 20 stations were obtained with the radio current meter. To supply information requested by the Navy, two other current surveys were carried out in San Francisco Bay.

The far-flung operations of our Armed Forces in the Pacific have been reflected in increased demands on the Bureau for tide and current data. During the year 24 comprehensive reports giving detailed information on tides and currents were prepared to meet special requests by the Army and Navy. In addition to these reports, more than 800 tide and light diagrams were prepared and over 81,000 copies were supplied on request. Special tide predictions and graphs were also prepared for combat areas. Four special tide and current tables, restricted to the Armed Forces, were prepared for the years 1945 and 1946, these publications giving daily tide predictions for 37 places and daily current predictions for 21 places in the western Pacific.

Reciprocal arrangements for the exchange of tidal information between the Bureau and England, Canada, India, and Argentina were in effect during the year. Agreements were made for the resumption of the exchange with France, which had been interrupted by the war, and for expanding the exchange with England. Since 1941 the publication of the Norwegian Tide Tables was forbidden by the Germans. In response to a request from Norway this Bureau supplied that country with special tide predictions for ten Norwegian ports for the year 1946.

During the year a total of approximately 138,000 copies of the regular and 77,000 copies of special tide and current tables were issued by the Bureau. This represents an increase of some 40,000 copies over the preceding year. Daily tide predictions for five additional stations were included in the regular tables to meet the need for such information in various parts of the world.

GEOMAGNETIC SURVEYS

The geomagnetic work of the Bureau began in 1840 as one of the essential steps in the preparation of nautical charts. As long as the navigator steers his vessel by the magnetic compass, so long will he require information on the amount the compass needle deviates from true north at any given locality. The nautical charts of the Bureau provide such information as do the aeronautical charts. The Survey is able to furnish such information as a result of its complete magnetic survey of the United States and the regions under its jurisdiction.

Geomagnetic surveys are also important to land surveyors in retracing boundary lines surveyed with the magnetic compass many years ago; to geophysical prospectors who use magnetic methods in their search for oil and other minerals; to investigators of radio transmission; and to other scientific investigators.

Because of the constantly changing direction and strength of the earth's magnetic forces, observations are necessary at periodic intervals. The present program of the Bureau calls for the determination of the magnetic elements at about 6000 "repeat stations" at 5-year intervals.

During the year continuous photographic records of the principal magnetic elements were obtained at the magnetic observatories at Cheltenham, Maryland; Honolulu, T. H.; San Juan, P. R.; Sitka, Alaska; and Tucson, Arizona. In addition, field observations were repeated at a large number of local stations well distributed over the United States. The latter observations supplement those of the observatories, being intended to constitute a comprehensive survey of the complex magnetic field covering the country.

To meet the military needs, special magnetic observations were made at certain sites. Special instruments were operated at some observatories for observations needed on naval research projects. Observations of magnetic declination were made at 67 airports in 31 states. This furnished the information required in airplane compass adjustment, a necessary preliminary to safe air navigation.

In the Washington Office, work continued on the production of a series of world-wide isogonic charts. Much urgently needed preliminary data, and many charts for specified areas, were furnished to such agencies as the Army Map Service, Army Air Forces, Hydrographic Office, Civil Aeronautics Administration, Geological Survey, Forest Service, Bureau of Mines, and Department of Terrestrial Magnetism of the Carnegie Institution of Washington. The principal applications of these data and charts were for safe air navigation and for studies of military and other radio communications.

Magnetic conditions based on records at the Cheltenham Observatory were reported daily to the National Bureau of Standards in connection with its program of forecasting radio transmission conditions.

Special compilations of data were prepared for use of the Weather Bureau in a research project.

Cooperation between the Bureau and the Department of Terrestrial Magnetism of the Carnegie Institution of Washington was continued. Geomagnetic data were exchanged and magnetic instruments loaned. Among the more important items were: Maintenance of international magnetic standard (sine galvanometer) and operation of a cosmic-ray meter at the Cheltenham Observatory; operation of an atmospheric electric observatory at Tucson, Arizona; and close collaboration in the matter of special instruments.

A large number of public inquiries were answered, providing specific data in most cases.

The following table shows the distribution of magnetic observations during the year: (Table on next page).

Distribution of magnetic observations

Location	Repeat stations				Other stations		Total
	New		Old				
	Complete*	Declination only	Complete*	Declination only	Declination only	Other	
Alabama	–	–	–	–	1	–	1
Arizona	–	–	1	–	1	–	2
California	2	–	5	–	5	–	12
Colorado	–	–	3	–	4	–	7
Delaware	–	–	–	–	1	–	1
Georgia	–	–	–	–	1	–	1
Idaho	1	–	1	–	1	–	3
Iowa	–	–	–	–	1	–	1
Kansas	–	–	–	–	2	–	2
Louisiana	–	–	–	–	1	–	1
Maine	–	1	–	6	3	–	10
Massachusetts	–	–	–	1	1	–	2
Minnesota	–	–	3	–	1	–	4
Mississippi	–	–	–	–	1	–	1
Montana	–	–	9	–	10	–	19
Nebraska	–	–	2	–	4	–	6
Nevada	1	–	5	–	1	–	7
New Jersey	–	–	–	1	–	–	1
New Mexico	–	–	3	–	1	–	4
New York	–	1	–	1	3	–	5
North Carolina	–	–	–	–	1	–	1
North Dakota	1	–	4	–	4	–	9
Ohio	–	–	–	–	1	–	1
Oklahoma	–	–	1	–	1	–	2
Oregon	1	–	4	–	2	–	7
Pennsylvania	–	–	–	–	2	–	2
Rhode Island	–	–	–	1	1	–	2
South Carolina	–	–	–	–	1	–	1
South Dakota	2	–	2	–	3	–	7
Tennessee	–	–	–	–	1	–	1
Texas	1	–	3	–	8	–	12
Utah	1	–	2	–	3	–	6
Vermont	–	–	–	1	4	–	5
Virginia	–	–	–	–	3	–	3
Washington	1	–	5	–	2	–	8
Wisconsin	–	–	1	–	–	–	1
Wyoming	2	–	3	1	6	–	12
Alaska	2	1	16	1	51	–	71
Hawaii	–	–	–	–	1	–	1
Mexico	2	–	2	–	–	2	6
Bolivia	2	–	1	–	–	–	3
Chile	3	–	–	–	–	–	3
Ecuador	2	–	–	–	–	–	2
Peru	3	–	3	–	–	–	6
Totals	27	3	79	13	138	2	262

*A "complete" station comprises measurement of declination, horizontal intensity, and dip, thus completely defining the field.

SEISMOLOGY

Seismology, or the science of earthquakes and attendant phenomena, is a comparatively new field of investigation for the Coast and Geodetic Survey. This work was assigned to the Bureau in 1925 when it was recognized that earthquake study was important to the country as a whole and that it must be dealt with on a highly cooperative basis. Because of its highly trained personnel, skilled in the operation of delicate recording instruments, and in the interpretation of records, it was the consensus of scientific opinion that this work should be taken up by the Coast and Geodetic Survey which for many years before had been operating seismographs at its magnetic observatories.

While it is true that earthquakes cannot be prevented, the practical purpose of the work is to discover ways and means of lessening their destructive effects. This can be done only by a systematic program of collecting and analyzing

data pertaining to earthquakes.

The program of seismologic work in the Coast Survey is designed to locate all significant earthquake areas in the United States and its possessions, to determine the destructive effects, as well as the nature of earthquake motions, and to safeguard life and property by giving to the engineer data which will enable him to determine where and to what degree earthquake-resistant designing of structures is needed. Progress has been made toward improvement of structural design as a result of the seismologic work of the Bureau. These efforts have aroused widespread interest in this country and abroad. Building codes have been improved and it is generally felt that lives and property are thus being materially safeguarded.

Seismologic information was furnished during the year to scientists, engineers, and individuals, as well as to special organizations, the military forces and other federal agencies.

Seismographs were operated, during the year, at four magnetic observatories and at the Ukiah Latitude Observatory. Sixty strong-motion seismographs were in operation at 52 stations in California, Nevada, Montana, Utah, and the Canal Zone. Twenty-two strong-motion records were obtained for nine earthquakes. The operation of seismographs in the regions of Boulder, Shasta, and Grand Coulee Dams was continued under a cooperative arrangement with the Bureau of Reclamation and the National Park Service, and special study of the accumulated data was made. Local tremors and ground level changes were correlated with water-level changes as the lakes filled, imposing billions of tons of water load. The possibility of damage to structures costing many hundreds of millions of dollars was thus appraised.

Vibration tests were made in six buildings to test the suitability of the sites for installation of sensitive seismographs. Four were in the western states, and two in the east. A long series of tests was made at a dam site in Washington State to determine the magnitude of vibrations transmitted through rock from nearby tunnel blasting. This was for the study of possible damaging effects on the setting of new concrete. Tests were made on another dam in Washington to correlate local vibrations with tremors recorded on a nearby seismograph. In this case the tremors were caused by discharge waters. In a New England mill building, measurements were made of the excessive earthquake-like vibration due to speeding up of the looms. The latter studies furnished data needed by engineers for designing buttresses and improving other construction detail of the buildings. In this way war production could be safely accelerated.

Three tilt meters were operated in California near earthquake faults -- two at Berkeley in cooperation with the University of California, and one at Long Beach in cooperation with that city -- to determine possible tilting of the ground. At Long Beach the observations also supplemented survey measurements of local land subsidence which is seriously endangering a highly developed water-front industrial area.

Earthquake investigation in the United States is a highly cooperative undertaking and involves close contacts with many commercial agencies and public utilities, the Weather Bureau, a number of seismologic and engineering organizations,

universities, postmasters, and hundreds of selected individuals. From them, nearly 2200 information reports were received for 331 earthquakes. In addition, special questionnaire coverage was made for 17 earthquakes which approached destructive character. Data obtained by the Bureau on destructive earthquake motions were used by the California Institute of Technology and the Bureau of Reclamation in special analytical investigations directed toward the efficient design of earthquake-resistant structures. Assistance was afforded 12 universities in maintenance of seismographs and 7 private stations through study and interpretation of their records In return they made available their recorded data, permitting their use, together with other data, in bettering the work of earthquake location.

Cooperation with Science Service was continued. This permitted the immediate location of important earthquakes from seismologic data transmitted by that organization. Thirty-three epicenters were located in this way. In exchange, the position reports made by this Bureau were made available to Science Service for local and general publicity purposes. They were also distributed to cooperating stations. Through the cooperation of the State and War Departments, information was obtained on earthquakes in enemy occupied territory.

Exchange of data was partially resumed with France, Belgium, and Russia, where the war had previously caused curtailment or discontinuance of normal programs.

IMPROVEMENTS IN INSTRUMENTS AND EQUIPMENT

A specialized scientific organization advances in proportion to its success in research and in adapting the current findings of science to its own needs. The Bureau has from its inception constantly aimed to test, develop, and employ new and improved instruments and equipment whereby better results can be obtained at reduced costs. The Bureau services the equipment and instruments used in its specialized functions. It has been found necessary to maintain a radio-sonic laboratory for improvements and adjustments of equipment used in electronics, and to provide a photogrammetric laboratory and technical group for the development of instruments and methods to give the precision required in this type of work.

During the year a new type of induction magnetometer was constructed and preliminary tests were completed. This instrument determines the magnetic meridian and measures the intensity of any component of the earth's magnetic field. It is unique in that it combines in one the functions of several existing types of instruments.

A field instrument to make continuous automatic records of declination at a fixed station was designed. The purpose of this instrument is to reduce the amount of field work and to improve our knowledge of declination changes for chart purposes.

Two high-magnification vibration meters of the Neumann-Labarre type were completed. Four are nearing completion. These are intended for the observation of extremely weak ground vibrations due to earthquakes and other causes.

The Bureau has developed an electronic-ranging device

which is now being tested at two places on the New England coast. This equipment, if successful, will replace RAR equipment for control of hydrographic surveys along the Atlantic and Gulf coasts. Unlike radar equipment, it is not necessary for the ship to be within sight of the shore stations for position finding. With this equipment offshore hydrographic surveys can be controlled by the operation of two shore stations. The operation of these stations will determine two distances to the ship so that its position can be plotted graphically.

Electric equipment for the accurate recording of rapid coastal-wave action was under development during the year. This instrument will permit the measurement of small-period wave oscillations which will be useful in the study of beach erosion and in the study of matters relating to waterfront construction.

A special vertical collimator was designed for precisely locating a theodolite, elevated over a mark on the ground. This development came about as a result of a request by the Navy to assist in the location of the guide rails for the new model testing basin at Carderock, Maryland. These rails control the movement of the ship model towing car with extreme accuracy and only a few thousandths of an inch error is tolerated in their alignment.

An improvement was made in the method of graduating geodetic level rods, which resulted not only in a greater accuracy in the graduations (a tolerance of 0.1 mm in the entire length of the rod, as compared with 0.3 mm formerly) but also in a less expenditure of time and effort.

Another improvement in equipment was in the design of a new all-metal signal lamp case made of aluminum. Formerly these lamps were mounted in wooden cases, but with the change in the method of conducting geodetic surveys, whereby four or more theodolites sight on a given station at one time, this system virtually precludes the use of wooden-cased lamps, because the lamps have to be stacked one atop the other in stacks of four or more lamps, which must lie in a vertical column. Any warping of the wooden cases would throw the column out of plumb and result in an error in the angle measurements. The satisfactory construction of this lamp was made possible by the application of a new method of welding known as Eutectic welding. This method makes use of a welding rod composed of the lowest possible melting temperature of the given alloy and permits carrying on welding at a temperature somewhat below the actual melting point for the parts to be welded, the rod melting first, fusing itself to the work with a strength equal to that of the basic material. This new lamp made it possible to eliminate the use of magnesium which was a war metal and not readily available.

An improvement was also made in the standard tide gage used by the Bureau, so that unusually high or low tides may be recorded. This was accomplished by redesigning the recording screw so that at each end there is a short section which has an entirely different pitch of screw than that of the main body. This is a very unusual mechanical feature to incorporate in any such apparatus, but the procedure for making it was worked out and a sample gage tried at the Washington station, with very satisfactory results.

The first plotting instrument for the nine-lens photo-

graphs was put in operation during the year This instrument was designed in the Bureau. Installation of a second plotting instrument for nine-lens photographs was in progress at the end of the year.

A new two-color press, identical with the one obtained in 1943, was placed in operation in November. This type of press is particularly effective on the long press runs required in printing United States aeronautical charts. The second press of this type produced 26,954,400 impressions during the year, which is the equivalent of 4,492,400 six-color charts.

A new knife-type folding machine, 38" x 52", which folds aeronautical charts lengthwise, was installed during the year to supplement the single folding machine of this type already available. A complete lubricating system and provision for rapidly drying ink through the use of gas heaters have improved the operation and output of the folding machines. Installation of steel rollers in lieu of rubber rollers on two Cleveland folding machines reduced the wear on the machines and made possible a more even fold. It has also reduced materially the amount of hand folding ordinarily required.

The addition of a revolute printer in the photographic work made possible the production of film positives in the large quantities required on Army Air Forces projects. During the year 39,261 film positives were furnished.

The Bureau has cooperated with various government agencies, particularly with the Navy Department, in the matter of furnishing them with drawings and specifications of instruments used in the Bureau and in aiding them in procuring equipment of Bureau design.

IMPROVEMENTS IN TECHNIQUES

At the request of the 311th Photo Wing, Army Air Forces, an investigation was made by the Bureau which resulted in attaining a greater accuracy in the velocity correction to be applied to measured Shoran distances. This velocity correction, the dielectric constant, is subject to the varying conditions of temperature, altitude, atmospheric pressure and vapor content of the air and its effect is determined for the time of observation by means of a formula. The formula in use, while satisfactory for the purposes originally intended, contained inaccuracies which made it unsatisfactory for mapping applications. Suggestions were made for further study of the problem in conjunction with field tests of the Shoran equipment, having in mind the application of radar methods in the determination of geodetic distances.

One photo alidade was completed by the Naval Observatory and delivered during the year. This instrument permits the drawing of form lines from oblique or horizontal photographs and is used principally in the delineation of Alaskan relief.

A Multiplex plotting machine for making topographic maps from single-lens vertical photographs was in operation during the year. It has been used in plotting 7-1/2 minute quadrangles in Virginia and for training purposes, both for our own employees and for the trainees from the American Republics. A second machine was purchased during the year,

and has been temporarily installed in Baltimore for starting a mapping program for the War Department.

Many improvements in methods of compilation, reproduction, and distribution have been made in connection with the nautical and aeronautical charts of the Bureau.

SPECIAL TRAINING OF BUREAU PERSONNEL

To keep abreast of new developments in fields related to surveying and mapping and to increase the efficiency of its employees, the Survey has undertaken a program of specialized training, both within and without the Bureau, for a number of the commissioned officers and departmental employees.

One commissioned officer and one technical employee completed special naval courses in radar training given at Bowdoin College, Brunswick, Maine, and at the Massachusetts Institute of Technology at Boston, Massachusetts. Following the completion of these courses and with knowledge of the advantage to be gained, six additional officers were enrolled for the same courses.

Arrangements were made with the Chief of the Weather Bureau in Washington, D. C., for courses to be given in meteorology and weather forecasting and six commissioned officers were given these courses in Washington. In Seattle, Washington, similar courses were attended by three commissioned officers.

Several commissioned officers and men of the crews of vessels based at Seattle during the winter months were given gunnery training at naval stations in the vicinity of Seattle.

Under the Inservice Internship Program of the National Institute of Public Affairs, one employee, who had been selected in 1944, completed a six-months' course of training. Job Instruction Courses of ten hours over a five-day period were continued throughout the fiscal year.

Trainee personnel were exchanged between the Washington Office and the field offices and survey parties to give these employees training and experience in all phases of the work, but particularly in photogrammetry. One commissioned officer studied several months in the Washington Office before taking over the planimetric mapping project at Portland, Oregon. The training of multiplex operators was begun and will be continued on an enlarged scale during the next year.

COOPERATION WITH AMERICAN REPUBLICS

As a part of the interdepartmental program, sponsored and financed by the State Department, for cultural and scientific cooperation with the American Republics, the Coast and Geodetic Survey continued its participation for the fifth consecutive year.

This program which began with the introduction of Coast and Geodetic Survey methods and instruments in gravity and tidal surveys in the Americas, has now been expanded to include work in other fields, such as geomagnetism, seismology, geodesy, and hydrography. In addition, there has been inaugurated, during the past year, a fellowship program de-

signed to train qualified applicants from the Americas in the fields of geodetic and hydrographic surveying, and map and chart production. The period of training varies from 4 to 8 months. No formal classroom work is given as the objective is to learn by doing rather than by theoretical studies. For those taking surveying, the major portion of the time is spent on actual field work with enough time in the Washington Office to become familiar with office methods of processing the field data.

Important benefits have already accrued from this cooperative program. Through our representatives who have visited the American Republics cordial and helpful relations have been established between this Bureau and military, naval, and scientific organizations and personnel. Through the fellowship-training program an effective medium has been provided for the mutual exchange of information on matters dealing with surveying and mapping which could become a potent force in developing a uniform procedure for such work and in cementing social and economic inter-American relations.

At the request of the State Department and the Petroleum Administration, a commissioned officer was sent to Barranquilla, Colombia,to cooperate with the port authorities in making a hydrographic survey of the entrance to the Magdalena River. Because of reports of a shoal in the channel, merchant ships refused to use it until an adequate survey was made. The hydrographic survey developed a safe channel into the river.

Twelve tide stations in Central and South America were operated on a cooperative basis, the Coast and Geodetic Survey furnishing and installing the instrumental equipment and the cooperating countries furnishing the necessary structures and observers. Two of these stations are located in Mexico, one each in Costa Rica, Venezuela, Colombia, and Ecuador, and three each in Peru and Chile. The observations from each station are analyzed in this Bureau and a copy of the results mailed to each cooperating authority. These data are being used for the prediction of tides, for the construction of nautical charts, and for the determination of various datum planes required in the development of coastal areas and in the study of coastal stability.

A representative of the Chilean Hydrographic Service spent six months in the Bureau studying the methods and procedures used in our tide and current work in order to introduce them in his country. Upon his return the Chilean Government extended, through the Department of State, an invitation for a representative of the Coast and Geodetic Survey to visit Chile to explore the possibility of establishing additional tide gages there.

Magnetic Surveys were continued in five American Republics, namely: Mexico, Ecuador, Peru, Chile, and Bolivia. Special diurnal-variation observations were made on the Galapagos Islands (Ecuador); at Ica, Chimbote, and Paita (Peru); and at La Paz (Bolivia). A special program of frequent repeat observations was started at Paricutin Volcano, Mexico, the new volcano which developed in a farmer's field in February 1943 and grew to over a thousand feet in height. A temporary magnetic observatory was established to supplement the field work. The purpose of these observations is to determine the extent of local magnetic disturbances caused

by this violent volcano.

A representative of the Bureau visited 13 of the American Republics to develop further cooperation in the acquisition and exchange of earthquake information. As part of this program, strong-motion seismographs have been furnished and installed in areas subject to strong earthquakes. Two were placed in 1944 (in Peru and Chile). The former has recorded a few weak shocks. Two more were installed during 1945 (in Colombia and Ecuador). Records resulting from this cooperative activity will be available to the Bureau and to the engineers of all American Republics. This is an active means of stimulating interest and improving knowledge in the countries concerned. The information gained will contribute to improved building design and add to the general knowledge of earthquake probabilities.

A number of the fellows have been instructed by their governments to furnish recommendations and cost data for the purchase of instruments, supplies, and equipment; and several countries have announced plans to send representatives to this country for the sole purpose of purchasing as a result of these recommendations.

Three commissioned officers of the Bureau attended the Second Pan American Consultation on Geography and Cartography at Rio de Janeiro, Brazil, as a part of our general cooperative program of acquainting ourselves with improvement in methods of surveying and mapping and to increase friendly relations with our neighbors to the south. All nations in the American hemisphere except Haiti, Honduras, and Nicaragua were represented. These Consultations, which are held under the sponsorship of the Commission on Cartography of the Pan American Institute of Geography and History, have for their purpose the adoption of uniform standards specifications, and working procedures among the various nations, so that the highest practicable degree of facility in interchangeable use will result. At the Second Consultation the general subjects discussed were: Geodesy and Astronomy, Aeronautical Charts, Topography and Aerophotogrammetry, Hydrography, and Cartography and Geography.

Under the fellowship-training program 11 fellowships in Map and Chart Production were awarded to: Bolivia (1), Brazil (5), Colombia (1), Ecuador (1), Mexico (1), and Peru (2); 8 fellowships in Geodetic Surveying to Brazil (2), Peru (2), Bolivia (2), and Ecuador (2); and 2 fellowships in Hydrographic Surveying to Peru (1) and Venezuela (1).

These fellowship grants are awarded to graduate engineers, preferably to those who have had experience and responsibility in the respective fields they are to pursue. Many of these fellows occupy high positions in the civil or military setups of their governments and the recommendations they take back are apt to be followed in those countries. Many of the representatives have expressed an intention of utilizing the training they received here to modernize their cartographic and reproduction methods and equipment to conform to those used by this Bureau. Dr. Allyri de Mattos, the technical chief of the National Council of Geography in Brazil, and one of the fellows under this program, was especially interested in our geodetic instruments, which he thought were more consistent and superior to results obtained with European-designed instruments.

PERSONNEL AND FINANCES

The number of persons in the service of the Coast and Geodetic Survey at the close of the fiscal year was 1924, distributed as follows:

Distribution of personnel by appropriations

	Commissioned		Civilian	Totals
	Permanent rank	Temporary rank		
Washington Office:				
Regular Appropriations	21	0	687	708
Working Funds	0	0	329	329
Total	21	0	1016	1037
Field Service:				
Regular Appropriations	93	16	611	720
Working Funds	0	0	167	167
Total	93	16	778	887
Grand Total	114	16	1794	1924

On 30 June 1945, 61 commissioned officers were serving with the armed forces, having been transferred by Executive Order. Of these, 12 had been transferred to the Navy, 12 to the Marine Corps, and 37 to the Army.

Of the officers transferred, 6 received the Legion of Merit, 3 the Silver Star, 19 the Bronze Star, 3 the Purple Heart, 2 the Croix de Guerre, besides numerous citations and letters of commendation.

During the year, 498 appointments (excluding temporary) were effected, 600 separations occurred, 14 employees were retired, 904 line promotions (including reallocations), 714 within-grade promotions were made, 1017 civilian employees had been given a deferred status under Selective Service Regulations, and 1029 had been inducted into, or volunteered for, the armed services, including 22 women and 1007 men.

Two officers were assigned to temporary duty aboard a Navy vessel in Long Island Sound to assist on special tests of radar equipment, for the Navy Bureau of Aeronautics.

Officers were assigned to the Fifth and Seventh Naval Districts to cooperate in making wire-drag investigations of wrecks along the North Atlantic and Florida coasts.

An officer continued on duty at the Headquarters of the Seventeenth Naval District at Adak, Alaska, as liaison officer between the Navy and the vessels of this Bureau operating in the Aleutian Islands area. This assignment has proven valuable in determining the survey requirements of the Navy, and in maintaining close contact with the field parties of this Bureau, so that assignments could be made to best fulfill the Navy requirements.

In the Philippine Islands two commissioned officers, Commanders C. A. Egner and Charles Shaw, one civilian employee, Vladimir Kovalevsky, and all dependents of Coast and Geodetic Survey personnel who had been interned in Manila since the beginning of the war, were returned to the United States. Definite word was received of the internment in Japanese prison camps of Lieut. George E. Morris, of Major C. F. Maynard, and of the death in Formosa of Lieut. (j.g.) J. W. Stirni.

This year marked the first year of service of any em-

ployees of the Bureau under a Wage Board. The majority of the employees in the mechanical group had favored the change; the artistic lithographers and copper plate engravers have not as a group been satisfied.

Collections covering miscellaneous receipts, including nautical and aeronautical charts and related publications totaled $166,876 as compared with $145,061 during the preceding year.

The following funds, from the sources indicated were available to the Bureau during the fiscal year 1945:

Available funds

Regular appropriation	$5,625,000.00
First Supplemental Appropriation Act, 1945	278,000.00
First Deficiency Appropriation Act, 1945	30,000.00
Total appropriations	5,933,000.00
Reimbursements to credit of appropriation for:	
Salaries	50,945.12
Aeronautical Charts	214,659.56
Coastal Surveys	574.39
Office Expenses	23,372.58
Total reimbursements	289,551.65
Working funds received from:	
Bureau of Reclamation (seismological work, Boulder Dam)	9,500.00
Bureau of Reclamation (seismological work, Coulee Dam)	2,000.00
Bureau of Reclamation (seismological work, Shasta Dam)	2,000.00
War Department (aeronautical charts)	1,845,071.00
War Department (control surveys in Alaska)	120,000.00
War Department (control surveys)	50,000.00
War Department (control surveys)	30,000.00
Navy Department (compilations of tidal data)	22,000.00
Navy Department (leveling project)	5,000.00
Total working funds	2,085,571.00
Allotments from:	
State Department (cooperation with American Republics)	86,500.00
Department of Commerce (printing and binding)	64,800.00
Department of Commerce (contingent expenses)	4,750.00
Total allotments	156,050.00
Total funds received	8,464,172.65
Of this, the following amount was unobligated June 30, 1945 and therefore remains available for 1946:	$194,278.06

PUBLICATIONS

In addition to its charts, the Bureau prepares a number of publications through which the results of its work are disseminated to the public.

In the field of related marine chart publications, ten supplements to the Coast Pilot volumes were issued during the year. These volumes contain a wide variety of important information which supplements that shown on the nautical charts. A new edition of a Pilot is published about every seven years, although this interval may vary depending on the importance of the region, the number of changes, and

other factors. Supplements, containing corrections, changes, and new information, are published about once a year. To meet the needs of shipping in the Intracoastal Waterway, Norfolk to Key West, a simplified Inside Route Pilot was issued.

A Philippine Islands Gazetteer, containing 47,000 original entries and cross references, was compiled and printed. Approximately 19,000 copies were issued to the Army and Navy.

A new and improved Chart Catalog, printed in the Bureau plant, was issued during the year. Over a long period of years, during which many new charts had been constructed, the chart indexes had become congested and confusing; the redesign of the indexes on larger scales is one of the major improvements in the new publication.

A new publication on projections, General Theory of Equivalent Projections, was completed. This is a valuable addition to the series of projection publications of this Bureau.

In the field of control surveys, a manual was issued entitled, The State Coordinate Systems (A Manual for Surveyors), for the purpose of encouraging the use of these systems by local engineers. Special tables to facilitate the conversion of military grid coordinates to geographic positions were computed for the polyconic grid at the request of the War Department.

In addition to the Tide and Current Tables which are annually issued by the Bureau, a revised edition of Tidal Bench Marks, Florida Gulf Coast was issued. This publication brings up to date the descriptions and elevations of tidal bench marks at 75 tide stations along the west coast of Florida. It is one of a series of publications compiled by states and localities which supply basic data to engineers and surveyors for establishing vertical control for hydrographic operations, coastal construction, and other engineering projects.

The manuscript for a revised edition of Surface Water Temperatures, Pacific Coast was prepared. This publication is based on temperature observations obtained at various Coast and Geodetic Survey tide stations and includes data furnished by the Scripps Institution of Oceanography for five stations located along the coast of California. The information is valuable to the shipping industry, to industrial plants using sea water, and to the fishing industry.

In the field of geomagnetism, Serial 663, Magnetism of the Earth was published. This new publication covers the whole subject briefly yet in sufficient detail to serve as a basic manual for those interested in geomagnetism or its applications. By reference thereto, more intelligent use can be made of the magnetic reports and publications of the Bureau.

Observatory reports completed during the previous year were issued. These reports comprise the principal record of the work of the observatories, being used in basic researches into earth magnetism and the ionosphere as well as for immediate practical application to charts.